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Insulation Wars

From the Editor . . .

We know that converts to a cause, whatever it may be, often become the most fanatical adherents. We've often seen that with tragic results among those who change religion or political beliefs. It makes for interesting academic studies, of which there are many. As a bit of a political junkie, this idea came across my mind as I observe the impact that Passive House is having.

We all know that our resource use, whether embodied energy or energy use for on-going operations, must be addressed. In the building sector, that means more energy efficient sustainable construction practices are imperative, and there is a lot of interest, not only among the idealistic builders and designers, but also among a growing portion of the public – the consumers of the buildings we build. Which is why the great interest in Net-Zero energy housing.

In Europe, Passive House is the energy efficient housing initiative that seems to have caught some traction. It is important to note the it was built on Canadian research and development work at the Saskatchewan Conservation House and the R-2000 program in the 1970s, and adapted in Europe to the European context. Unlike the R-2000 Standard that applies only to dwellings built under Part 9 of the Building Code, Passive House is meant to be equally applicable to larger scale non-residential buildings. The energy target, an aggressive performance based energy target, is set at 15 kWh/m^2 per year, which is slightly more stringent than the new R-2000 standard.

Although it is a performance-based building standard, Passive House also certifies products that are considered suitable, so that manufacturers promote the Passive House in their marketing. The impression is thus given that certified products must be used, and we see various European products being marketed in Canada now.

There is nothing wrong with foreign products – some really enhance performance and productivity and are worthy of consideration. Before the current Canadian government stopped supporting housing exports, we also promoted use of Canadian products as part of Canadian style housing, although it was done without the fervour of the Passive House folks.

However, compliance with the Passive House standard relies on a very rigorous and academic analysis. Unlike R-2000, builder training is not a mandatory part of the program, but intensive training is provided for designers and evaluators. I have observed that they have done a good job promoting the training that resembles a combination of the builder training and energy advisor training initially developed for the R-2000 program.

Although the principles are built on building science, which is universal, it's the details used in the application that are subject to interpretation. Canadian construction practices have evolved over many years, and have been continuously evolving as we've been improving general construction standards including energy efficiency. European construction practices are different, and this shows up in the Passive House approach. The consequence is an overly complex academic administrative process that does not make it builder friendly.

I have had discussions with some designers and builders that have set out to build in accordance with Passive House principles. When I questioned them, and suggested alternatives that might be easier to build or be more economic, the answer invariably comes back that it's not an acceptable Passive House detail. If Passive House has laid it out, it's the gospel, and don't bother with anything else. And don't bother questioning whatever quirks have been built into the criteria or the software because it cannot be challenged. Like converts to a new religion, they seem to lose sight that there are many ways of achieving high performance, sustainable building.

If we're going to make progress to achieve truly efficient, sustainable and Net-Zero construction buildings we need to be able to entertain new ideas and take advantage of new tools and materials. It's great to get enthusiastic buy-in from new participants who will champion the cause – these are vital to help spread the word. But we need to be careful not to create a new religion with a set of dogmas that cannot be challenged.

Richard Kadulski
Editor

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Insulation Wars

The need to improve building performance through more aggressive energy codes and the desire to address climate change issues means that the way houses are built is changing.

Although improvements in mechanical systems for heating and cooling of buildings have had a big impact on reducing energy consumption, it has been well known for a long time that the most effective energy reductions are building envelope improvements. What gets built into the shell of the building will do its job without reliance on occupants, pumps or motors and their maintenance or lack thereof.

Achieving a well performing building envelope requires rethinking how construction assemblies are designed and built. It is well known that when you consider the effect of framing elements in an assembly, the actual insulation value of the assembly will be significantly different than the value of the insulation alone. That is why codes now are moving to require *effective* R-values, rather than relying on the *nominal* R-values of the past. What this means is that you cannot assume that the 2x6 frame wall packed with a R-20 batt of fiberglass insulation gives you a R-20 wall.

By considering the effective R-value, recognition is given to the impact of thermal bridging through non-insulating elements of an assembly. R2000 and ENERGY STAR® for New Homes emphasize higher performance building envelopes and have been doing calculations based on the effective R-values for some time.

The market has responded with innovative insulation products and novel building enclosure systems such as various types of spray foam and spray-applied fibrous insulations, exterior insulated sheathing, structural insulated panel systems (SIPS), insulated concrete forms (ICF), etc.

Until the recent past, there were basically two main types of insulation widely used in construction – fibrous products and cellular plastics. The Canadian insulation industry has been dominated by two manufacturers. Each has trademarked colours for their products. The major fiber manufacturer features pink, and at one time used pink flamingos in their marketing before they switched to the Pink Panther. The other is a major chemical company featuring cool blue for their cellular plastic insulation.

However, there are other manufacturers and products in the market and some of those product types are starting to gain significant market share. The use of spray foam insulation in residential construction has exploded in the last few years. Spray foam insulation is one of the fastest growing products in building construction.

With more attention given to insulation, manufacturers are launching new products and using new aggressive marketing. What looks like the first volley in an insulation war against competitors has been launched by Owens Corning. They have initiated an "industry conversation" targeted at the spray foam industry. Although they state that they are not "targeting the SPF community as a whole" they have launched a website (*www.insulatewithintegrity.com*) where they have posted a limited number of third party documents from the USA chosen to leave a very negative impression about spray foam insulation, but leave warm and fuzzy feelings about fiberglass batt insulation.

The negative impression is created in a very slick brochure titled *"Spray Polyurethane Foam: Separating fact from fiction."* In the brochure, fiberglass is presented as the best and most benign insulation material without any negatives, while all potential issues with spray foam are highlighted.

It is important to point out that there is no single product that does everything. Every product has its unique characteristics and properties, benefits, environmental impacts, and performance characteristics – both positive and negative. Each must be evaluated carefully as to where the products are to be used – some materials may be better suited in some applications than others.

Safety issues

Owens Corning highlights the importance of safety issues. This is an important point, as with all construction materials and processes, some safety precautions are needed. The specifics of protection needed depends on the product and location of its application.

The major difference between fibrous and board-stock insulation materials and spray-in-place foam is that the spray foam product is effectively manufactured on site. This means

that installers must be qualified, be properly protected, and no others should be on site for the duration of the foam installation and for the curing time. Installer protection includes full-face air respirators and chemical protective clothing, making them look like aliens or high hazard hazmat crews. For an outside observer, this may be very frightening, but it's something that happens in all kinds of processes, usually in a closed factory environment.

It is important to note that most of the references that Owens Corning uses are US based. This deserves emphasis because there are very significant differences between Canada and the US in the spray foam industry. One source of media stories about problems with foam is due to the improper installation of foam insulation by unqualified installers or do-it-yourselvers in the US.

In the US, the onus on qualifications is with the installers, so there may be less than qualified applicators installing the foam improperly. The Owens Corning document points out that OSHA (the US Occupational Safety & Health Administration) strongly *recommends* that spray foam installers be trained. In Canada, they *must* be trained and licensed.

Although the manufactured chemicals may come from the same source, in Canada all spray foam must conform to Canadian standard CAN/ULC-S705.1-*01 Standard for Thermal Insulation - Medium Density Closed Cell Spray Applied Rigid Polyurethane Foam* for closed cell (2-lb) medium density spray foam, or CAN/ULC-S712.1-10 *Standard for Thermal Insulation - Light Density, Open Cell Spray Applied Semi-Rigid Polyurethane Foam* for open cell (½-lb) spray foam.

These are material standards that include how R-values are calculated. This is especially important for the closed cell medium density (2-lb) foam, as its R-value degrades somewhat from the initial installation. That is why the Canadian standard sets out criteria for calculating long-term thermal R-values (LTTR). The Canadian LTTR values are the ones that must be used and not the US values. In the US, the long-term values are taken at 90 days, but the gas diffusion and decay of the insulation values is longer.

A quick scan of the product specs on the website of one foam manufacturer shows the R-value on the US site is listed as 6.75/inch, while on the Canadian website the LTTR value for the same product is listed as 5.5/inch.

The Canadian standards each have a part two that sets out requirements for installation of spray foam insulation. The application standard includes requirements for installer qualifications and that installers must carry photo-identification card. It sets out installation requirements for environmental conditions (including temperature criteria for installation), substrate preparation and limitations for product installation. There are also criteria for spill containment of materials and on-site testing which includes density, adhesion and cohesion tests.

The installer must properly store material and decontaminate and dispose of empty drums properly. Installers must also maintain complete documentation including a prescribed Daily Work Record. Every manufacturer also must have a third-party organization to operate a field quality assurance program.

CAN/ULC S712.2, the installation standard for the open cell foam, is similar to that for the closed cell foam but it is still at the draft stage so has not been officially released.

Performance Standards

Spray foam proponents tout that insulating the whole house will make it easy for the builder to achieve high levels of airtightness. While spray foam is an excellent material for air sealing, especially irregular framing conditions and rim joist areas of engineered wood floor joist assemblies, insulating the whole house is not a guarantee that airtightness will be achieved. There may be some areas such as the gaps between built-up framing members that still require air sealing.

Fiberglass batt installations must also be installed properly to achieve maximum performance, and this requires diligence on the part of the installer. The high quality of installation required is often challenging to achieve due to sloppy application and because installers are often paid on a piecework basis, so have every incentive to move quickly.

One published technical study posted on the Owens Corning website was a study of a couple of walls in Seattle, with stucco cladding over OSB sheathing, insulated with open and closed cell spray foam. The study found moisture-induced failure for the open-cell foam insulated wall. The study was done in 2008-2009 and the paper was presented at the Buildings XI conference in December 2010. A major conclusion was that a rain screen wall assembly (which was not part of the study) would be a way to avoid such problems. A useful addition to the body of research but the conclusions were substantially out of date by the time it was published.

A lot of similar work was done in Vancouver in the 1990s, both as simulation and test panel monitoring, which led to wealth of information about the performance of wall assemblies. The conclusions of those studies was that capillary breaks behind the exterior cladding (i.e. rain screens) are necessary to ensure building durability. Those findings led to code changes mandating rain screen construction on the west coast, and many consultants are pressing the importance of such detailing regardless the climate zone. ☼

Insulation Performance

Insulation is evaluated by the R-value which is a useful tool for comparing the resistance to heat flow of various products. R-value is a well-established and widely accepted tool for describing the thermal performance of building insulation materials but it is an incomplete one for describing the thermal performance of building enclosure assemblies.

Testing is done with a fairly small temperature difference – with a warm side of 38°C ± 5°C and a cold side 10°C ± 5°C. In reality, building envelopes are subject to wide temperature changes during which materials expand and contract, gaps and paths open and close, and the thermal performance of the assembly can change. A more appropriate test would be done over a wider temperature range, reflecting a more realistic temperature range, with a warm side of 22°C and a cold side of -20°C, but that would require a change to the testing protocols.

The testing does not account for air (convection), moisture or vapour flows. This is important as some insulation materials permit more airflow through the material than others. If there are gaps a convection air current could be created, driven by the temperature difference between the interior and exterior, that would move heat out, thus lowering the effective R-value of the insulation. On the other hand, other insulation products are airtight (and qualify as air barriers) so their effective R-value is unchanged.

In recent years, the focus of building code and regulatory officials, professionals and researchers has shifted towards the performance of the entire wall system, so it is not good enough to characterize the wall by its R-value alone, as was the case in the past.

Because new insulation materials and systems control heat flow in new and non-traditional ways, they are more or less sensitive to thermal bridging, workmanship (i.e., quality of installation), internal convection, and through convection (i.e., infiltration, exfiltration, and wind washing). The impact of such anomalies and defects is not captured by the R-value. The difference between the actual heat flow and that predicted by combining R-values increases as the temperature difference and the net resistance to heat flow increases. These realizations have generated a growing interest in the development of a new metric for measuring thermal performance.

The National Research Council has had a project to develop a new way of looking at thermal performance of wall assemblies – the Wall Energy Rating (WER). The main objective of this project is to develop an accurate and reliable combined testing and analytical procedures to determine the wall energy rating of insulated wall assemblies. It introduces a new concept that combines the heat loss due to air leakage and that due to thermal conduction showing their interaction and impact on the overall thermal performance of wall assemblies.

The WER procedure is a tool for building designers and construction professionals that could be used to comply with current or future energy code requirements. The project was initiated and funded mainly by the foam industry. However, lack of funding, and little interest on the part of other sectors of the insulation industry means it will be a while before the WER is further developed to a state that can be universally used as a design or regulatory measure. ☼

Heat Transfer Modes

Conduction is the flow of heat through a material by direct contact between two materials. Materials with a very low thermal conductivity are considered to be insulation materials.

Fiberglass batt insulation is widely used as insulation despite the high conductivity of glass because of the large proportion of air-filled pores – fiberglass insulation is about 99% air. Foam plastic insulations have a lower percentage of air voids than glass fiber, but are made of lower conductivity plastic.

Convection is the transfer of heat by the movement of molecules in a liquid or gas. This is an important heat transfer mechanism between fluids and solids (think of a pot of water on the electric stove). Still air is a good insulator, so insulation materials generally are low-density, low conductivity porous materials with a large portion of air filled voids.

Radiation is heat transfer by electromagnetic waves through a gas or vacuum so radiant heat transfer requires a clear line of sight. It is heat flow from a warmer surface to a colder surface. Think of the sun and earth in full sunlight compared to under the shade of a tree or overhang. In buildings, it is the windows and skylights (transparent elements) that are important for radiant heat flows, but not the opaque elements.

Within porous insulations, all three modes of heat transfer occur simultaneously. At low densities, the effective conductivity is high since convection and radiation can move heat through the relatively open space.

At high densities, convection and radiation are suppressed, but conduction becomes important. The optimum density varies with the type of material. For fiberglass the optimum density is about 30 kg/m^3, but commonly used densities are closer to 15 kg/m^3. ☼

How Accurate Are Energy Models?

We live in a digital age. We rely on apps for everything. Computer analysis and simulation has become the norm today. The computer outputs are accepted as definitive, and in some cases govern us. However, it is important to have some perspective and to be realistic about what a computer program can and cannot do.

Building simulation programs are complex tools with a diversity of inputs, many of which rely on assumptions about average use and occupancy conditions. Although many of us rely on these tools, and dwell on the last 21 kWh, we need to keep in mind a comment made by Michael Blasnik, a Boston-based building science consultant who states point blank that all models are wrong, but some are useful at some times.

The issue is especially important when dealing with existing houses. Today's homes will be with us for a long time - most houses of 2050 are already built. Upgrading the houses to improve performance is going to have a much bigger impact on overall energy use and greenhouse gas reduction than just relying on new construction to reduce energy use, because annual new construction represents less than 1% of total number of homes. However, making existing homes more energy efficient is difficult which is why policy makers and utilities have created energy retrofit programs. The impacts of the programs, on which the incentives are based are estimated by simulation programs.

Blasnik has reviewed a number of retrofit program evaluation and analysis tools, to check how actual energy use compared to the modelling projections in a number of US energy retrofit programs. He found that the predictions of energy use against actual use varied widely – as much as 25 to 50% from predictions. Generally they were overly optimistic.

Are the tools flawed? All programs used accredited modelling tools, but the standard against with they are validated is based on testing with another piece of software, so we have software testing other software. (Artificial intelligence gone wild?)

Why bother with these modelling tools if they are flawed? They are used because incentive programs still need some credible basis on which to make decisions about what changes merit attention and require incentives.

The accuracy and reliability of the modelling tools is influenced by the simplifications and assumptions that are used in the tests, and the acceptable tolerances. Not everything can be known or modelled with any degree of accuracy, especially for existing houses, so assumptions must be made, especially about use and occupancy, occupant behaviour and climate variations. The lights, appliances and how people use them, the temperature settings they keep, and their tolerance for temperature swings, are just some of the unknowns that do have an impact on house performance, but are also highly variable and not readily known.

In Canada, HOT2000 is the most widely used program for code compliance and retrofit programs. It has been validated not only against other software programs, but also against actual monitored housing performance data. However, accuracy of the results still depends on the assumptions used.

For new construction, there are fewer construction assembly unknowns because we know the full construction specifications. But there will still be some variations as to how they were put together, how well the systems were commissioned, and of course the big unknown – occupant behaviour. At best, modelling tools are like the mileage tests for vehicles – for new construction they provide a basis for comparison, but based on a number of assumptions. In the end, the best check for the accuracy of the modelling is to look at billing data for actual energy use once the work is completed.

In very high performance houses, energy use for space heating will be very small, and energy use is dominated by hard to model factors, such as hot water consumption, internal gains from the occupants themselves (number and age of the people and their pets) as well as the appliances, lights, and plug loads. If there is a drain water heat recovery unit, the recovery performance will depend on usage patterns.

Solar gains are a big item. How much shading there is, and when, will also affect the house performance. Even how clean the windows are can affect how much sun enters the building.

So when we look at different programs, we need to keep these factors in mind.

Peter Amerongen, the Edmonton builder who built the EQuilibrium house in Edmonton, and has moved on to build a number of Net-Zero Energy houses, has worked with both HOT2000 and the Passive House modelling software.

The Passive House (PHPP) software requires extremely detailed inputs. He points out its more detailed analysis gives designers more control over important details and offers the ability to test and modulate thermal bridging details. But the detail required makes it a specialty analysis.

One example of software variation is that while HOT2000 assumes 100% of possible solar radiation reaches the building, PHPP uses a more detailed shading analysis. The HOT2000 simplification can lead to significant over estimation of useful solar gains. But neither approach can properly address the variability of weather, or the impact of landscaping, which is highly variable.

HOT2000 does have the advantage that input is relatively quick, and has been tested and verified in all Canadian climates, and has a more accurate ground heat loss analysis. But both PHPP and HOT2000 need to be fine-tuned and verified for use in very low energy and Net-Zero energy homes.☼

In Memoriam: Gus Handegord

Gus Handegord, a Canadian pioneer of building science research, passed away March 19, 2014 at the age of 90.

Gus Handegord began his building science career as a lecturer at the University of Saskatchewan. He joined the National Research Council of Canada (NRC) Division Building Research (DBR) in 1948, and moved to Ottawa in 1968 to continue a 35-year career with the National Research Council until he retired as Head of the Building Practice Group in 1983 and entered private practice.

Handegord is the author of numerous technical and research papers, as well as two definitive books on the subject: *Building Science and the Building Envelope* and co-author of *Building Science for a Cold Climate*.

He was not only a researcher and author, but also taught at the Southern Alberta Institute of Technology, Carleton University School of Architecture, University of Waterloo Environmental Studies, and the University of Toronto School of Architecture and Civil Engineering as well as being a guest speaker.

His many contributions have been acknowledged by professional organizations in Canada and the US.

You Asked Us About: Use of Polyethylene in the Basement

It's been suggested that we don't need to use polyethylene when building a house, especially in the basement. How do we do that and remain code compliant?

You raise an excellent question, which touches on what the code requires, and the perceptions of what the code calls for. The building code has quite a bit of flexibility, and does permit multiple ways of detailing, but sometimes it requires some interpretation. As most users are comfortable with simple prescriptions, industry practices often become so engrained that they become the norm, and any deviations raise questions about whether or not they are code compliant.

The use of poly has become the most common detail for air sealing because industry has become used to it. Caulking and sealing of the poly on the inside does double duty – it is *both* an air barrier and a vapour barrier and inspectors can inspect the caulking. The use of poly as the air/vapour barrier was popularized starting in the late 1970s when energy efficiency first started being treated seriously. The importance of air sealing was understood and advocated. Since vapour diffusion control ("vapour barrier") is needed, it was pointed out to builders that combining the two was one relatively easy way to achieve the desired airtightness.

We now understand there are nuances to the forces acting on building assemblies. Basement walls now have to be insulated, and moisture as well as heat flows need to be managed. However, insulating a basement wall requires that we reconsider construction materials and details or we will increasingly see problems.

Basements represent a special case, because the environmental forces acting on basement wall assemblies are different than on above ground assemblies. A basement wall can see a significant temperature gradient not just across the wall but also from top to bottom.

The top of the wall at grade is exposed to outdoor extremes with large daily and seasonal temperature variations while the deeper it gets, the more constant the temperatures with year-round cold and wet conditions on the outside. Unlike an above-grade wall that sees variable conditions on both sides, and can dry out on a seasonal basis, below grade basement walls can only dry one way – inward. Only the upper part of the basement wall, at grade, will be able to dry outward.

The building code requires an air barrier (9.25.3) and a vapour barrier (9.25.4).

The requirement for an air barrier is a material or assembly that has the "characteristics necessary to provide an effective barrier to air infiltration and exfiltration under differential air pressure due to stack effect, mechanical systems or wind." (9.25.3.2) The code then goes on to discuss the importance of caulking and sealing the connections between different materials in order to maintain continuity of the air barrier when there are penetrations or connections between materials.

Thus any material in an assembly, including concrete, framing, drywall, plywood or OSB can be an air barrier as long as the continuity of the air seal across connections is maintained. The air barrier can be in any location – on the inside, on the outside or part way through the assembly, and it can cross from outside to inside – depending on the material. The only critical issue is that the material does not impede vapour diffusion if it is at a point where it could lead to moisture build up and condensation.

The code also requires a vapour barrier to control the diffusion of water vapour. Clause 9.25.4.2 defines the properties of a vapour barrier: it must have a permeance not greater than 60 ng/(Pa•s•m^2) measured in accordance with *ASTM E 96/E 96M – Water Vapor Transmission of Materials*, using the desiccant method (dry cup). Thus any material with a permeability less than 60 ng/(Pa•s•m^2) satisfies the code requirement for a vapour barrier.

Although the code spells out the properties that polyethylene needs to have if it is a vapour barrier and an air barrier, the code *does not* require the use of polyethylene. [The vapour permeance of polyethylene is about 1.6 – 5 ng/(Pa•s•m^2).]

The commonly accepted practice of placing polyethylene on the interior of a furred basement wall prevents any drying of that wall, so there can be moisture build-up and rotting of the wood. This moisture build-up can often be seen in new construction before the basement is finished. Renovators see it when a finished basement is gutted.

However, there are materials that have a variable permeability but yet comply with code requirements. Sometimes referred to as 'smart' vapour barriers, these products have a slightly greater vapour permeability that permits drying of construction moisture and thus avoids the build-up of moisture, mould and rot. They have the look and workability of the conventional poly sheets yet provide adequate vapour diffusion resistance.

Currently, the market leader is MemBrain a product developed in Europe and marketed by CertainTeed. This is a polyamide (nylon) film that changes its permeability with the ambient humidity condition to permit drying. This is an option for when the basement is not being finished at construction. Testing was done to show compliance with code requirements (9.25.4.2) is described in the CCMC report No. 13278-R. The air leakage rate through the MemBrain also conforms with the code requirement for an air barrier. Other European manufacturers have developed similar products that in time we may see in Canada.

If the basement is being finished, then another alternative is the airtight drywall approach, where careful air sealing is done and gasketed to the drywall, and a vapour barrier paint is applied to the drywall to provide the vapour diffusion control.

The property of a variable permeability is not unique to these new membranes. Plywood and OSB both have similar characteristics which is why when on the inside, they can be used as the vapour barrier (depending on thickness). We can also use them as sheathing on the outside face of frame walls above grade because the permeability increases with high humidity, permitting moisture diffusion through them until the humidity is reduced. And we have a long time experience with these products without any issues.☼

Research at the National Research Council has pointed out that we need to rethink how we build basements. The research report is titled ***Performance Guidelines for Basement Envelope Systems and Materials*** authored by Michael C. Swinton, IRC/NRC

Dr. Ted Kesik, University of Toronto. It is very readable, and worth looking at.

It is available on the NRC website, but because the NRC site is difficult to navigate, the most direct access to the document is to Google the document title.

Master of Engineering in Integrated Wood Design Training

The University of Northern BC in Prince George, and home to Wood Innovation and Design Centre, at 30 meters (100 feet) the tallest wood building in the world, is about to launch a new wood design training program. The proposed Master of Engineering in Integrated Wood Design will be housed at the new building.

The Integrated Wood Design training program is being developed to meet emerging needs as wood is increasingly used in more diverse and larger structures. New engineered wood options are being developed, making it easier to be used in larger buildings. This is because wood is being recognized as a more sustainable material as it originates from a renewable resource. It is also cheaper to build with wood, and it provides excellent seismic stability, is carbon neutral, and can have health benefits beyond what other building materials can provide.

This one-year program is being designed to enhance the students' understanding of wood as a versatile and sustainable building component. Students will understand wood at a micro and macro level, explore the science and art of connecting wood, and study iconic structures of the world from an engineering and architectural perspective.

Dr. Guido Wimmers has been named as the inaugural program head. Wimmers holds a PhD in building science from Leopold-Franzens University in Innsbruck, Austria. He moved to Canada in 2007 and was part of the team that designed the innovative Austria House in Whistler for the 2010 Winter Olympics. He has been a key champion of the Passive House in Canada.☼

Canadian Home Builders' Association

Technical Research Committee News

Net-Zero Energy Housing Council

The concept of Net-Zero Energy (NZE) Homes has generated considerable interest among the public and attracted considerable interest within governments, the home building industry, building material and product suppliers, as well as some policy-makers and environmental advocacy groups.

In keeping with this increased public interest, CHBA has established a Net-Zero Energy Housing Council. A survey of members and others in the housing industry found there is significant interest and value in CHBA's involvement in the Net-Zero Energy housing area. This builds on the growing interest in high performance and Net-Zero housing, and the association's long-term involvement with innovative housing programs such as R-2000.

The central premise behind the NZE home concept (including Net-Zero 'ready' homes) is optimization of energy efficiency combined with on-site use of renewable energy to achieve a home that, on an annual basis, requires no net purchased energy. At present, such homes involve a significant cost premium and have limited commercial viability. However, this cost premium has fallen dramatically in recent years, and is likely to fall further in the future.

To date the best recognized NZE housing initiative in Canada has been CMHC's EQuilibrium project although a number of other pilot and demonstration initiatives have also occurred or are underway currently. While a number of CHBA member builders have participated in these NZE housing projects, or undertaken NZE home development on their own, to date CHBA has not taken an active role in this area.

NZE homes will remain a 'niche' product for some time, but efforts to develop viable commercial approaches will influence housing research investments by governments and manufacturers. There is also some potential for increased commercial viability of NZE housing to trigger calls for further regulation of the industry by environmental advocates and others that stand to benefit from such actions.

The council will also provide a forum for CHBA to take a more active and leadership role in the Net-Zero housing area. It will help influence developments related to Net-Zero housing consistent with the interests of the home building industry and its customers. The Council's success will be measured by the increase in numbers of Net Zero houses built and sold as well as building cost reductions through technical innovation.

Thermal Barriers for Spray Foam Insulation

The National Building Code requires that foam insulation must be protected by a thermal barrier. There is an exception if the foam is in a crawlspace or attic not generally accessed, or within a wall assembly. The code further defines acceptable materials as plaster, gypsum board, plywood, hardboard, particleboard or any product that conforms with criteria set out in CAN/ULC-124: *Test for the Evaluation of Protective Coverings for Foamed Plastic.*

With the greater use of spray foam insulation to provide insulation and air-sealing for details such as rim joists, the protection of the foam plastic can be a challenge. One example is a rim joist insulated with foam insulation in an insulated but unfinished basement. A common approach is simply to use batt insulation, and stick a polyethylene sheet to provide air and vapour diffusion resistance. However, sealing a sheet material between joists, especially if they are engineered joists, is virtually impossible to do properly and maintain an air seal.

Sensing a market niche to exploit, Roxul tested their mineral wool products and have announced that their 5½" Roxul Comfortbatt® and 2 & 3" Comfortboard™ IS have been tested and comply with the thermal barrier requirement in accordance with CAN/ULC S124-06. These products meet the requirements of a thermal barrier as specified in 9.10.17.10(1)(c) and 3.1.5.12.(2)(e) of the 2010 National Building Code of Canada.

Energy Answers

Rob Dumont

In a previous column I laid out some directives for a decent, energy efficient home. The Directives are meant for cold climate houses in Canada, the northern United States and other high latitude environments.

I circulated the previous column to a group of professionals working in the area, and asked for their comments. In this issue I am incorporating their recommendations for changes and improvements to the Directives. My thanks to Peter Amerongen, Martin Holladay, David Olivier, Gary Proskiw, Monty Samson, RonnLepage, Harold Orr, Marc Rosenbaum, Tony Korte, Ken Kelln, Angie Bugg, Juergen Korn, Ken Guido, Chris Richards, John Hockman, and Tim Mayo for their inputs.

The revised directives have been influenced by their comments, but I take full responsibility for the changes that have been incorporated. I have tried to keep the directives relatively short, so have not included any diagrams or lengthy explanations. No product names are referenced but I recommend *Consumer Reports Magazine* and *Buyers Guide* as guides to efficient and generally reliable products. NRCan's Office of Energy Efficiency has a searchable product listing that lists energy efficiency of different product models. *http://oee.nrcan.gc.ca* The US Energy Star Web site *www.energystar.gov/products* is also a useful guide to energy efficient products. For potable water-saving devices look at *www.epa.gov/WaterSense/products/.*

When designing and building, make sure that all applicable building, plumbing and electrical codes are applied. Remember that these codes are generally minimum standards for health, safety and structural sufficiency. The Directives recommend higher than minimum standards in many areas.

The issue of designing appropriate housing is an age-old issue. Socrates , who lived from 470 to 399 B.C. at a time when there was a shortage of firewood in Greece, is quoted as follows by Xenophon," … *his dictum about houses… was a lesson in the art of building houses as they ought to be. Now in houses with a south aspect, the sun's rays penetrate into the Porticoes (porches) in winter, but in the summer the path of the sun is right over our heads and above the roof, so that there is shade.*"

In our times, all buildings, including houses, account for 40 to 50% of the total energy used. We have a social responsibility to build in a much more environmentally appropriate manner. These directives are meant to help those wanting to build houses as "they ought to be " in this era of global warming.

Directives For A Decent, Energy Efficient Home

1. Design
2. Lot Selection
3. House Shape
4. Design for flexibility
5. Trees
6. Garage Type
7. Contractors
8. Windows
9. Thermal mass
10. Insulation levels
11. Air tightness and mechanical ventilation with heat recovery
12. Space Heating/Cooling and Domestic Water Heating
13. Renewable Energy
14. Cooling/Air Conditioning
15. Efficient Water Use.
16. High Efficiency Lighting.
17. Energy Star Appliances
18. Safety
19. Durability
20. Think multiple uses, low impact materials

1. Design. Don't scrimp on design. Design fees are a small part of the overall cost of a new home. Be prepared to pay a little extra (5 to 10% or more) for a good design. Do not use plan books or standard plans as too often the designs will not work for energy efficiency, for your location, or for your lot choice.

For most people, their largest single investment will be their house, so it pays to get the design right.

Rob has summarized his thoughts on issues to consider for designing and building an energy efficient house. The piece is too big for a single issue – so we have decided to serialize it over the next two issues. This issue we are presenting part one.

Choose a designer with proven experience with energy efficient design. Ask to see some samples of their work. A good designer can often save you money. The key to good design of an energy efficient home is *balance.* While there are many things that can be done to save energy, the costs and benefits of the various options vary tremendously. A good designer should be able to select those upgrade options that produce the greatest savings at the lowest cost.

Third-party verification from a recognized agency will help you benefit from the improvements when the time comes to sell the property. It will also help you avoid the pitfalls of wishfully thinking that the measures you happen to prefer will have great benefits.

For a very useful talk on the design of very efficient houses, have a look at Peter Amerongen's presentation on Youtube (search for: "*approaching net zero energy at the lowest possible cost*"). Peter is an Edmonton builder who has built more Net Zero Energy Houses in Canada as of 2014 than any other builder.

2. Lot selection. Select a piece of land with good solar access. The lot should have unobstructed access to the direct sun from about 8 am to 4 pm each day of the year. Watch out for solar obstructions from trees and adjacent buildings on the south, southeast and southwest sides of the lot. A wide south facing lot is preferable to a narrow lot. The wide lot allows for more south window and solar equipment to be installed.

The lot need not face exactly south. It can face plus or minus 30 degrees of south with little loss of annual performance compared to a lot facing due south. In most places you can determine south either from maps, a compass, or by observing where the sun is between about 11 am and 1 pm. (Except in the extreme north, where there are times in winter when the sun does not rise above the horizon.)

3. House Shape. Choose a shape for the house that is roughly rectangular with the long axis of the house running east and west. Avoid plan shapes that are L shaped, T shaped or U shaped. Avoid "bonus rooms" over top of an attached garage. It is difficult to provide space heating, ventilation, plumbing, and fire separations for such spaces. The L, T and U shapes have more surface area and heat loss for the volume that they enclose, compared with a rectangular-shaped house plan. Long, narrow, trailer- shaped houses should also be avoided for the same reason.

4. Design for flexibility. A well-designed house should last for centuries, and over that length of time many different uses will be made of the space in the home. As an example, provide a separate entrance to the basement of the house and design the basement space so that a kitchen, bathroom and living space can be incorporated at a later date. Another approach is to design an upper story of the house with a separate entrance and living space. Have the plumbing and electrical systems roughed in so that a separate suite can be readily developed at a later date. Take a look at the CMHC documents on Flex Housing.

Make sure that all codes regarding zoning, spatial separations and safety are respected. In general, space above ground is much more useful and valued than space below ground. Basement spaces can have problems with privacy, security, and water entry through windows and walls, as well as ground water tables and flooding.

The National Building Code of Canada has specific requirements specified for "Secondary Suites". The basic requirements are for some fire and smoke separations and for separate and non-interconnected forced air heating, cooling and ventilation systems for each of the "dwelling units".

For accessibility reasons, keep the main floor entrance of the house at grade level. As people age, there is a greater need to avoid stairs. Plan ahead so that stairs are minimized and an elevator or powered stairlift can be readily added at a later time. Avoid details like sunken floors, with their accident-prone steps or changes in elevation. Design the entry, hallways, doors, kitchen, bathroom and at least one bedroom to accommodate a wheelchair. Provide grab bars. Colour can be used to increase visibility of tripping hazards. There are many other features that could be added to improve livability and safety for those with physical challenges.

Good design is not easy. Combining a grade level entrance to the main floor with windows in the basement takes some creativity in the exterior grading.

5. Trees. Some books on house design suggest placing deciduous (leaf-bearing) trees on the south side of the house and evergreen (needle bearing) trees on the north side of the house. I do not agree with placing deciduous trees on the south side because trees will grow to a great height and block the sun on the south side of the house. Although leaves will fall off in the heating season, the branches do not fall off. Some trees have a very dense branching that will obstruct a good part of the sun's rays. A modest number of dwarf evergreen trees on the north side is all right.

If you must have deciduous trees, choose dwarf varieties that will not block the sun summer or winter. All trees should be located a good distance from the house to prevent leaves and needles from settling on the roof and plugging the gutters and downspouts. Never have a tree that overhangs the house or garage; in major windstorms the tree can crash into the building. During high wind storms or ice storms, electric power outages often occur because of trees striking the power lines.

Some trees have aggressive root systems that can affect foundations if the roots penetrate under the foundation if they are too close. In locations with expansive clay soils, trees too close to the house will also affect the moisture content of the soil which can affect the foundation.

6. Garage. If you want a garage and have the space on the property, a detached garage is preferable to an attached garage for safety reasons. People have died in homes with attached garages from car motors running and producing carbon monoxide which drifts into the living space. Some people also store highly flammable and toxic materials such as gasoline cans, propane cylinders, fertilizer, herbicides, solvents, and pesticides in garages. Cars have been known to spontaneously start on fire from an electrical short.

If you choose an attached garage, make sure than an excellent air barrier and fire barrier are incorporated between the garage and the living space, and that you have a carbon monoxide sensor in the living area – this is now a requirement in the National Building Code.

Prewire or place an electrical outlet in the garage or close to where a car would be parked so that electric cars can be charged once electric cars are more widely available.

A 40 amp 240 volt circuit is usually the minimum needed for a fast charger. For a slow charger, a 15 amp 120 volt circuit is usually sufficient. A 240 V circuit may cut the charge time to 1/4 of that of a 110 V connection.

For more information on electric vehicles and electric vehicle chargers: *www.plugincars.com* or the Vancouver Electric Vehicle Association web site (*www.veva.bc.ca*)

7. Contractors should have experience in building energy efficient construction such as R-2000 houses. Ideally the contractor will have input on the design and should be reasonably competent with all aspects of the houses: building enclosure, heating, ventilation, electrical, controls. The contractor should also understand the principles of house-as-a-system to prevent back drafting of chimneys from excessive negative pressures in the house, although the best approach is to avoid chimney-vented appliances. The only exception are solid fuel burning appliances.

8. Windows Choose windows with great care. Windows are usually the most expensive part of the walls of the house on a cost per unit area basis. On the south side, put windows with an area equal to about 6 to 8% of the floor area of the house. Thus if the floor area of the main floor of the house is 1,000 square feet, the south window area for that floor should be in the range of 60 to 80 square feet.

A formula for sizing south windows in houses with conventional wood frame construction and gypsum board interior finishes is:

South window area = 8% of floor area x 0.66/SHGC of south window

SHGC (solar heat gain coefficient) is the fraction of the solar radiation striking the window that enters through the glazing and becomes heat gain.

Approximate values for the solar heat gain coefficients of common types of windows used in colder climates are shown in the following table (next page).

There has been a lot change in the window industry in recent years, so there are many glazing options available today. Your window supplier should be able to give you specific values for the glazing they use.

Using south windows that exceed the size suggested in the above formula will result in overheating the house unless additional thermal mass is incorporated. Overheating will likely occur in September and early October, when outdoor temperatures are relatively warm and the solar gains from windows on sunny days are significant. The CMHC publication *Tap the Sun* has more information on this subject.

Window Type	Solar Heat Gain Coefficient (SHGC)
Double glazed, clear glass with no low e coatings	0.66
Double glazed with one low e coating(e= 0.1 on surface 3	0.55
Triple glazed clear glass with no low e coatings	0.62
Triple glazed with one low e coating (e= 0.2 on surface 2	0.57
Triple glazed with two low e coatings (e=0.1 on surfaces 2 and 5)	0.38

Note: All windows in the above table are assumed to be fixed (non-operable) with non-metallic frames with individual glass thicknesses of 1/8 inch (3 mm) Source: ASHRAE Handbook of Fundamentals, 2005. The surfaces count from the outside in. Thus surface 3 on a double glazed window would be the outside surface of the inner glazing layer.

Fixed windows are preferable to operable windows (windows that open) and are usually less expensive and have narrower frames and admit more light and solar energy. However, building codes require a minimum size of opening windows for egress and summer ventilation/cooling in most rooms. Windows that are hinged tend to have better air tightness than windows that slide, but hinged windows tend to have more problems with window opening hardware such as cranks.

On the south side, choose windows with a solar heat gain coefficient of 0.55 or higher. To control unwanted solar gains on south windows in the cooling season, provide a roof overhang or awning that will shade the south windows. At solar noon on June 21, the angle of the sun above the horizon is 61 degrees at locations with a latitude of 52 degrees. At more northern locations, the corresponding sun angle would be lower. Thus at latitude 62, the sun angle at solar noon on June 21 would be 51 degrees. You can use this angle to size the external fixed shading device. At 49 degrees, this typically is a 3-foot overhang on an 8-foot wall.

Limit the window area on the east and west sides because windows in these orientations provide little passive solar heating in the heating season but contribute to overheating the house in the cooling season. An alternate is to use a " heat rejection" Low-E coating to reduce heat gain. Windows on the north side contribute little to useful space heating, and for this reason should be limited in area. On the east, west, and north walls, choose windows with a high R value (low U value).

The HOT-2000 computer program can be used to fine tune a design for energy efficiency.

9. Thermal mass. Place inexpensive thermal mass in the home. A simple way to do this is to place scrap gypsum board in the hollow wall cavities of interior wood stud wall partitions. This technique will also reduce the amount of landfill waste during construction and save on tipping fees.

10. Insulation levels. I am a great believer in high insulation levels. My family home in Saskatoon was one of the best insulated houses in the world when it was built in 1992. The house has R-80 in the attic, R-60 in the above grade and basement walls, and R-35 in the basement floor joists. The walls are about 16 inches thick (400 mm) and use blown-in cellulose insulation. A double wall high-R-value wall was used in the Riverdale Equilibrium house in Edmonton. Details of the walls construction have been documented, and are available in CMHC document 66737, available at: *http://www.cmhc-schl.gc.ca/odpub/pdf/66737.pdf*

Insulation in the basement floor is important. If a concrete floor slab is used in the basement, place insulation under the slab. Expanded polystyrene (beadboard) is usually the least expensive rigid insulation to use and a minimum of 3 inches (75mm) thickness should be used. Make sure that there is a thermal break around the perimeter of the slab.

A recent study by Gary Proskiw and Anil Parekh recommends the following attic insulation values for homes that strive to be net zero in annual energy consumption:

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Vancouver – R-60 to R-80;
Toronto – R-80;
Winnipeg – R-80;
Yellowknife – R80+.

To convert R-values to RSI (metric) values, divide the R-value by 5.678. Thus R-60 would be equal to RSI 10.6.

Because wall insulation is more expensive than attic insulation due to additional framing or more expensive insulation materials, the above-grade and below-grade walls usually should have R values about 70% of those in the attic.

The HOT-2000 computer program can be used to calculate the effectiveness of insulation.

(to be continued in next issue)

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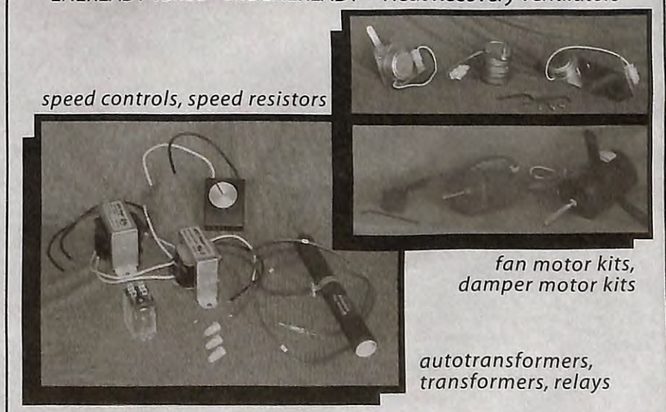
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